Statement of Under Secretary Steven E. Koonin
U.S. Department of Energy
Before the
Subcommittee on Energy & Water Appropriations
U.S. House of Representatives
FY 2012 Budget Hearing
March 16, 2011

Chairman Frelinghuysen, Ranking Member Visclosky, and Members of the Committee, thank you for the opportunity to appear here today to provide an overview of the President's Fiscal Year 2012 budget request for the Department of Energy's Office of Science. I will describe a few of the highest priority research areas in the Fiscal Year 2012 Budget request, but first let me explain why the Office of Science and the basic research it supports matters.

Why Basic Research Matters

In his recent State of the Union address, President Obama said, "In America, innovation doesn't just change our lives. It is how we make our living." That's not just rhetoric – it is true. Scientific research is at the core of a high tech economy. Most directly, it increases our knowledge of Nature and integrates that knowledge in ways that are directly useable for practical engineering applications. And in the course of their work, as researchers develop new tools and techniques that allow us to discover and measure previously inaccessible physical phenomena, those tools form the basis of new technologies or solutions to long-standing technical barriers. Scientific understanding is at its most practical when it solves problems that arise in the design, manufacture or operations of complex technologies. Finally, research is a prime training ground – though not the only one – for a technically talented workforce that can drive future innovation.

The Office of Science provides 45% of Federal support for basic research in the physical sciences, and key components of the Nation's basic research in materials, biology, and computing. The Office of Science supports over 27,000 PhDs, graduate students, undergraduates, engineers, and supports staff at more than 300 institutions. Researchers supported by the Office of Science or making use of our scientific user facilities have won over 100 Nobel Prizes in the past 60 years – 22 in the past decade alone. The Office of Science provides the world's largest collection of scientific user facilities to over 26,000 unique users from universities, national labs, other federal agencies and businesses large and small each year. The Office has been the source of research funding for many of those who are now engaged in the national conversation on energy.

To help explain the research supported by the Office, I offer four stories that I believe illustrate the benefit we provide to the Nation; there are many others I could have chosen.

Environmental Microbiology. Microbes far outnumber all other forms of life on the planet. They and their biochemistries are far more varied than the plants and animals we are most familiar with. While some microbes are well-studied, particularly those that cause disease, we have a very limited understanding of how they do an amazing range of things, including degrading biomass, transforming heavy metals at contaminated sites, and breaking down oil. One of the problems is that microbes exist naturally in communities of several interdependent species, so that they cannot be isolated and grown in the lab. To address this problem, our Biological and Environmental Research program supported development of a new technology called the GeoChip, which provides a rapid, real-time snapshot of an environmental sample that tells us what microbes are present and what they're doing. . The original GeoChip won an R&D 100 award in 2009; each new generation allows researchers to have an increasingly complete view of microbial activity. This small but powerful tool advances our understanding of environmental microbiology, letting us engineer more effective communities for contaminant mitigation, oil spill cleanup, or carbon sequestration.

A New X-Ray Laser. Since all material is made of atoms, we are driven to develop new tools that better see those atoms and what they're doing. The new Linac Coherent Light Source (LCLS) at Stanford University's SLAC National Accelerator Laboratory is the world's most powerful X-ray free electron laser. It creates flashes of light bright enough to make images of single atoms or molecules and fast enough, like a stroboscope, to capture their motion. The LCLS is opening new frontiers in economically relevant fields like materials science, electronics, energy research, and the life sciences. One of the first LCLS experiments showed for the first time that protein structures could be obtained from tiny nanocrystals otherwise too small to use. Since many medically-important proteins are difficult or impossible to crystallize, this novel capability can take years off the search for new drug targets. In a separate study, the same team reported making the first single-shot images of intact viruses, paving the way for snapshots and movies of viruses and microbes in action.

Smart Truck. A long-haul truck typically puts on five times as many miles as your car does in a year, yet gets only 1/5 the gas mileage. So improving vehicle efficiency matters a lot to truckers, with independent drivers getting hit particularly hard by rising fuel prices. Using the Office of Science's Jaguar supercomputer located at Oak Ridge National Laboratory (the world's second fastest), Smart Truck Brands, an engineering services firm in South Carolina, developed bolt-on fairings for trailers that substantially reduce fuel consumption. That small start-up developed the most detailed (and therefore the most accurate) numerical model of a Class 8 truck and trailer ever created. World-class simulation capabilities allowed them to rapidly refine designs for their UT-6 Trailer UnderTray System. These add-on parts can be easily retrofitted to existing or new trailers to improve MPG by 10% to 17%. If all 1.3 million Class 8 trucks in the U.S. were configured with these components, companies could achieve annual savings of 1.5 billion gallons of diesel fuel – approximately equal to $5 billion in costs – and reductions of CO2 by 16.4 million tons. The Office of Science developed its simulation methods and supercomputers for basic research, not to improve the efficiency of long-haul trucks. But as you can see, we actively reach out to people working on energy problems who can benefit from our expertise and our machines.

Creating a High Tech Workforce. Basic research supported by the Office of Science helps develop the skills and capabilities of the Nation's high tech workforce. Rudolph Technologies, a 550 employee New Jersey firm producing control sensors for semiconductor processing, is working with Brookhaven National Laboratory on a new tool for measuring materials properties at the Lab's National Synchrotron Light Source. Even though the work is not immediately related to the products Rudolph is developing today, the company uses the collaboration to expand its own capabilities and to engage with the Brookhaven's student and postdoctoral researchers, a talent pool from which to recruit the next generation of company scientists.

The FY2012 Budget Request: Investments for the future

I would like to turn now to some of the highlights of the FY2012 Budget request. The President is requesting $5.416 billion for the Office of Science, an increase of $512 million or 10.4 percent over our FY 2010 appropriation. With your support, we will continue to make progress toward President Obama's commitment to double funding for key basic research agencies, a commitment that continues the prior Administration's American Competitiveness Initiative. This request has a clear investment strategy – to support those areas of science most directly impactful on the energy, security and environmental missions of the Department. These are materials and chemical sciences, biology, and computational sciences.

Such clear priorities meant some tough choices for fields such as high energy physics, my own field of nuclear physics, and fusion energy. The Office of Science supports nearly 90 percent of research in elementary particle physics in the U.S., nearly 80 percent of basic nuclear physics research, and 100 percent of fusion research. Yet in this budget climate, we propose to hold High Energy Physics flat, redirect resources in Nuclear Physics from operating facilities to construction of the next generation of world-class facilities, and reduce the top line for the fusion program. I will discuss those later.

Materials by Design. One of the reasons you hear us say materials over and over again is that the materials discovery and improvement drives many of the most significant technological innovations. Until today, those discoveries and improvements have almost always been the result of time consuming trial and error – "shake and bake." As part of an interagency effort, the President's FY 2012 Budget requests funding to support work that tightly couples materials synthesis, testing, and modeling to more rapidly explore and refine new substances for applications ranging from batteries and electronics to lightweight structures.

In the Office of Science, our focus is on materials useful in extreme circumstances, such as in nuclear reactors or other power systems where there are corrosive, high-temperature, and/or high-radiation environments. Corrosion costs about 3% of the U.S. gross domestic product every year, according to a Federal Highway Administration's study, "Corrosion Cost and Preventive Strategies in the United States" (Publication No. FHWA-RD-01-156). Some recent work convinces us that the simulation-based, materials-by-design approach we propose holds great promise. A research team using Argonne National Laboratory's supercomputers wanted an answer to the fundamental question of how materials become brittle. The researchers simulated the introduction of small amounts of sulfur into the grain boundaries of nickel, which is used in nuclear reactors for valve stems or control rod drive mechanisms. The surprising results let them understand exactly how sulfur impurities cause microscopic fractures to grow into the larger cracks that cause failure.

Biosystems by Design. Biological systems hold powerful capabilities that are already being tapped for clean energy and environmental solutions. Reengineered microbes and plants can harvest sunlight and store that energy in the molecules that they use to power metabolism or we can use as renewable biomass. To take fuller advantage of these bio-based capabilities we need to better understand the design principles that govern living systems and to systematize design rules for the rapid reengineering of microbes and plants. The Budget request provides funding for new research to identify, characterize, and articulate general biological design principles, and to create new synthetic molecular toolkits to improve understanding of natural systems; the ultimate goal is computer-aided design and testing of natural and hybrid biological systems to rapidly develop multiscale natural and hybrid biological systems for clean energy and environmental solutions. This more systematic approach to bioengineering is poised to stimulate a new biotechnology revolution, much as DOE efforts fostered the genomic sequencing revolution more than two decades ago.

Energy Systems Simulation – Internal Combustion Engines. In 2008 the United States had some 300 million automobiles and light duty trucks on the road using approximately 130 billion gallons of gasoline per year. Yet there remain significant opportunities to improve the efficiency and cleanliness of internal combustion engines. Scientific simulations of what happens inside a cylinder can help us better predict, and optimize, engine performance. Of particular importance is understanding liquid fuel injection (where and when the fuel is placed in the cylinder) and fuel ignition and burn. The U. S engine industry has identified these as high-priority engineering science challenges as they move from hardware-intensive, experience-based engine design to simulation-intensive, science-based design. Coordinated efforts between the Office of Science and the Office of Energy Efficiency and Renewable Energy will result in tools to simulate combustion of diverse fuels in real engines; they will be broadly useful to any engine designer, rather than specific to one company or another.

Investments for Exascale Computing. A theme running through most of priorities is high-performance computer simulation. The U.S. has been a leader in high performance computing for decades. Recently, it is quite clear that other countries, having seen both the utility and promise of supercomputing to further their own economic, scientific, and security interests, are rapidly gaining ground, and have already surpassed the U.S. in some dimensions. Losing a competitive capability in this field would have far reaching consequences for the nation.

For more than twenty years, our supercomputers have been built from increasingly powerful commercial off-the-shelf components. But to realize the thousand-fold increase in capability we believe possible over the next decade, we must decrease power consumption, increase the number of processing units on a single chip, more tightly integrate memory and processors, and ensure that millions of processors work well together, even as some will inevitably fail. To begin attacking these problems, the FY 2012 budget proposes a joint activity between the Office of Science's Advanced Scientific Computing Research program and the National Nuclear Security Administration's Office of Advanced Simulations and Computing that will deliver the design for a cost effective, useable, and energy efficient exascale capability by the end of the decade.

New and Continuing Energy Innovation Hubs. The Energy Innovation Hubs are particularly promising ways for the Department to focus its research efforts on those problems where the close integration of discovery-oriented science with translational engineering research can accelerate commercialization of new technologies.

- ***Fuels from Sunlight Energy Innovation Hub.*** The FY 2012 budget requests the third year of funding in the Office of Science for the recently established Joint Center for Artificial Photosynthesis. The challenge is to design highly efficient, non-biological, molecular-level "machines" that generate fuels directly from sunlight, water, and carbon dioxide. The goal is to demonstrate a scalable, manufacturable solar-fuel generator that produces fuel from the sun ten times more efficiently than current energy crops. The Joint Center's R&D focuses on accelerating the rate of catalyst discovery for solar fuel reactions; discovering earth-abundant, chemically and mechanically robust, inorganic light absorbers designed to use more sunlight than natural materials do; and providing system integration and scale-up.

- ***Batteries and Energy Storage Innovation Hub.*** This new Hub in the Office of Science will develop electrochemical energy storage systems that safely approach theoretical energy and power densities with that can be charged over and over without losing capacity. Improved energy storage is critical for enabling the widespread use of intermittent renewable energy, electric vehicles, and efficient and reliable smart electric grid technologies. These are systemic challenges requiring new materials, new systems, and new knowledge. The Hub will address key fundamental questions in energy storage including: How closely can we approach theoretical energy density? Can we safely increase the rate of energy utilization? Can we more efficiently move electrical energy in and out of storage?

With the support of this committee, the Department funded three Hubs in FY 2010 including the Office of Nuclear Energy's Modeling and Simulations Hub for Nuclear Reactors, which is using substantial computational resources provided by the Office of Science's Oak Ridge Leadership Computing Facility.

High Energy Physics. The High Energy Physics program seeks to understand how the universe works at its most fundamental level. The research focuses on the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time. The Tevatron Collider at Fermilab concludes its planned program in FY 2011. Its record-breaking performance in delivering data over the last few years is important, but the attention of the particle physics community is turning to the energy frontier now at Europe's Large Hadron Collider (LHC). The Tevatron dataset collected over the last few years will continue to be mined for discoveries while the LHC begins generating data. Strong support for neutrino physics and dark matter searches continues as the program concentrates its efforts on retooling our domestic facilities to exploit discoveries of rare processes at the intensity frontier.

Nuclear Physics. Our Nuclear Physics program is not solely a discovery-oriented fundamental research program focused on exploring and understanding all forms of nuclear matter. The program also has responsibility for the Isotope Production program, which has produced for over 50 years radioactive and stable isotopes used in research and commercial applications. The FY 2012 budget request terminates operations of the Holifield Radioactive Ion Beam Facility (HRIBF), a facility for studying nuclear structure and astrophysics at the Oak Ridge National Laboratory, in order to ramp up design work on the next-generation radioactive ion beam facility to be built at Michigan State University. The FY 2012 budget request supports operations at the three remaining nuclear physics national user facilities at levels that will allow continued scientific progress.

Fusion Energy Sciences. The Fusion program works to understand matter at very high temperature and so build the scientific foundation needed to develop a practical fusion energy source. The FY 2012 Budget emphasizes developing within the domestic program the science for predictive understanding of plasma properties, plasma dynamics, and interactions with surrounding material. The Administration gained agreement from the ITER Council and ITER Organization to a range of U.S. initiatives that implement management reforms and accelerate ITER construction; the goal is to minimize the overall cost of the Construction Phase for the U.S. and other ITER Members. A decrease in proposed ITER funding reflects the Administration's assessment of the level of effort required to sustain U.S. commitments in FY 2012.

Bioenergy Research in Office of Biological and Environmental Research. Advanced biofuels are a critical component of a sustainable energy future, requiring innovative research strategies to support the aggressive production goals Congress has set in the Energy Policy Act of 2005 and help reduce our nation's dependence on oil. Our three Bioenergy Research Centers (BRCs) led by Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the University of Wisconsin with Michigan State University are making the scientific breakthroughs that will allow us to more effectively convert the cellulose in plant fibers to biofuels and optimize those plants as clean energy crops.

A core capability provided by BER through its Joint Genome Institute (JGI) is high-throughput genome sequencing of non-medical microbes, microbial communities, plants, and other targets relevant to DOE missions in energy, climate, and environment. This work underpins modern systems biology research, providing fundamental data on key genes that link to biological function. Like all of our scientific user facilities, the resources of the JGI are made broadly available to researchers based upon scientific merit. For example, Dr. Daniel Peterson, a plant geneticist at Mississippi State University, was part of a team of USDA-funded researchers awarded time at JGI to sequence the loblolly pine, an important crop for the pulp and paper industries.

Climate Research in Office of Biological and Environmental Research. Starting in the mid 1940s, civil defense needs and the testing of nuclear weapons created an urgent need to understand the global distribution of radioactive fallout. That need drove the development of what became the first global circulation models and that expertise in climate modeling still contributes today to DOE's sophisticated nuclear nonproliferation programs. DOE's current climate models focus on understanding timescales from decades to centuries—information needed to plan for future energy use, land use, food production, and water resources and to help mitigate economic and finance risks in infrastructure planning. Work in the Office of Science focuses on two of the greatest uncertainties in climate modeling—clouds and aerosols. The BER-supported Atmospheric Radiation Measurement (ARM) Climate Research Facility is used by hundreds of scientists around the world to better understand the physics of sunlight in the atmosphere. Several ARM sites carefully located around the world study diverse atmospheric conditions, but the main 160-acre site just outside of Lamont, Oklahoma is one of the best instrumented columns of air on the planet. While carbon dioxide is a key contributor to climate change, water vapor is the dominant greenhouse gas in the Earth's atmosphere. ARM data and improved calculations during the past decade have reduced uncertainties in water vapor measurements from 13% to less than 4%, enabling better weather forecasts of temperature and humidity in the upper atmosphere.

In closing, I would like to recognize the efforts of our career Federal staff in the Office of Science and its service centers in Chicago and Oak Ridge. Implementing programs of the scale, pace and quality of the Office of Science takes remarkable dedication and concerted effort. I thank you for the opportunity to appear today and look forward to further discussions of the Department’s priorities.